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IN RE APPLICATION OF: Sven-Rune OLOFSSON, et al.

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FOR: IMPROVEMENTS IN, OR RELATING TO TELECOMMUNICATIONS

REQUEST FOR PRIORITY UNDER 35 U.S.C. 119 AND THE INTERNATIONAL CONVENTION

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

In the matter of the above-identified application for patent, notice is hereby given that the applicant claims as priority:

COUNTRY	APPLICATION NO	DAY/MONTH/YEAR
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Certified copies of the corresponding Convention application(s) were submitted to the International Bureau in PCT Application No. **PCT/SE99/00121.** Receipt of the certified copy(s) by the International Bureau in a timely manner under PCT Rule 17.1(a) has been acknowledged as evidenced by the attached PCT/IB/304.

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Improvements in, or Relating to Telecommunications

The present invention relates to:

- a POTS splitter, for separating analogue telephony signals from xDSL signals, including a line testing device;
- a telecommunications system, incorporating POTS splitters including line testing devices, at customer premises; and
- a method of testing a subscriber's line.

A network operator who wishes to introduce a broadband service, for instance xDSL (Digital Subscriber Line), must be able to measure certain parameters for a wire pair that is to be used to deliver the service. This is necessary both to ensure that the service can be successfully provided and to enable the network operator to guarantee service quality. There are many advantages if the measurements can be performed on a two sided basis. This means that a signal source capable of transmitting test messages/signals, upon request, must be placed at the customer's end of the line. The results of applying a test message/signal to the line at the customer's end are measured at the CO (Central Office) end. The present invention provides an active POTS splitter ("Plain Old Telephony Service" splitter) which includes this testing functionality.

When delivering a broadband service, such as xDSL, without inband POTS, it is necessary to separate the analogue POTS signal and the xDSL signal from each other at both the CO (Central Office) and the CP (Customer's Premises). This can be achieved by using analogue passive high pass and low pass filters. Figure 1, the accompanying drawing, illustrates this principle.

However, a passive POTS splitter design lacks the performance of an active splitter design, see J. Cook and P.Sheppard, "ADSL and VADSL Splitter Design and Telephony Performance", p.1634, December 1995, IEEE Journal on Selected
Areas In Communications, ISSN 07-8716. This results in either:

- poorer POTS transmission; or

- if the cutoff frequency of the low pass filter in the splitter is increased, a waste of valuable spectrum that could otherwise be used to support higher data rates in the xDSL modem.

If an active POTS splitter design, with impedance matched circuits, is used, the filter design criteria become more reasonable while, at the same time, the spectrum, or bandwidth, use becomes more efficient, without degradation in the ordinary telephony transmission. The preferred solutions, especially as xDSL becomes more common, is the active POTS splitter design, or inband POTS (which implements the telephony service as a part of the xDSL data stream).

If the active splitter design is used and the splitter is implemented on a single chip, the present invention proposes the incorporation of test functionality for the line between the CP and the CO, or ONU (Optical Network Unit), on this chip. This enables two-sided measurements on the line, both during installation and during operation. The measurements are performed at the CO end upon request, or when the test device automatically sends a test message/signal. In this way there will be no need for field technicians at the CP side. If necessary these chip can have a unique identity code that is transmitted to the CO each time a test is started, or on receipt of a request from the CO.

The test messages/signals should either be specially designed for a certain measurement case, or general applicable signals which can be used with a range of tests, e.g. pulses, steps, or chirps, to estimate the transfer function of the line. One example of a parameter requiring two-sided measurement is attenuation. The test sequence could, in this case, be a series of sinusoidal signals, with known amplitude, sent from the test device to the CO, in sequence. The sequence can, for example, comprise 10, 100, or any other number, of tones, starting from either low, or high, frequency and then varying in frequency towards the other side of the frequency spectrum. Each tone is transmitted for a relatively long period of time, so that synchronisation is not a problem and so that the measurement can be performed within the duration of a tone. The start of a test may occur at a predetermined time interval after a test message request.

According to a first aspect of the present invention, there is provided an active POTS splitter adapted to separate analogue POTS signals from xDSL signals, characterised in that said active POTS splitter incorporates line testing means.

Said testing means may be adapted to transmit a test signal, or test message, to a line to be tested.

Said test signal may be adapted for the performance of a specific line test.

Alternatively, said test signal may be of a general form capable of use with a range of different line tests.

Said test signal may comprise at least one pulse.

Said test signal may comprise at least one step.

Said test signal may comprise at least one chirp.

Said test signal may comprise a series of sinusoidal signals of known amplitude, each signal in said series having a different frequency, said series spanning a frequency range for which a line is to be tested.

Each tone of said series of sinusoidal signals may have a duration of a length sufficient to avoid problems associated with synchronisation and to permit a measurement to be completed within said duration.

Said test means may be adapted to transmit said test signal, or message, on receipt of a request signal.

A test facilitated by said test means may be initiated at a predetermined time interval after receipt of a request signal by said test means.

Said test means may be adapted to transmit said test signal, or message, automatically.

Said test means may be adapted to transmit said test signal, or message, in accordance with a predetermined schedule.

Said test means may have a unique identity code, and said test means may be adapted to transmit said unique identity code whenever a test signal, or message, is transmitted, or whenever an identification request signal is received.

Said test means may be adapted to short-circuit a line.

Said active POTS splitter, including said test means, may be implemented as a single chip.

Said chip may be mounted on a PCB connected to a line jack adapted for direct insertion into a customer premises line socket.

According to a second aspect of the present invention, there is provided, in a telecommunications system adapted to employ xDSL and POTS, and comprising at least one central office connected to a plurality of subscribers by subscriber lines, a method of measuring quality parameters relating to xDSL transmission on a subscriber line, characterised by the steps of:

- generating a test signal on said subscriber line at a subscriber's premises;
- performing measurements at said central station on said test signal as received at said central station; and
- deriving quality parameters for said subscriber line from said measurements.

Said test signal may be generated by causing said subscriber line to change from a high impedance state to a low impedance state.

Said test signal may be generated by causing a telephone to switch from an "on-hook" state to an "off-hook" state.

According to a third aspect of the present invention, there is provided, in a telecommunications system adapted to employ xDSL and POTS, and comprising at least one central office connected to a plurality of subscribers by subscriber lines, each subscriber premises being equipped with a POTS splitter, a method of measuring quality parameters relating to xDSL transmission on a subscriber line, characterised by the steps of:

- said POTS splitter generating a test signal on said subscriber line;
- performing measurements at said central station on said test signal as received at said central station; and

- deriving quality parameters for said subscriber line from said measurements.

Said test signal may be adapted for the performance of a specific line test.

Said test signal may be of a general form capable of use with a range of different line tests.

Said test signal may comprise at least one pulse.

Said test signal may comprise at least one step.

Said test signal may comprise at least one chirp.

Said test signal may comprise a series of sinusoidal signals of known amplitude, each signal in said series having a different frequency, said series spanning a frequency range for which a line is to be tested.

Each tone of said series of sinusoidal signals may have a duration of a length sufficient to avoid problems associated with synchronisation and to permit a measurement to be completed within said duration.

Said test signal , or message, may be transmitted on receipt of a request signal.

A test may be initiated at a predetermined time interval after receipt of a request signal.

Said test signal, or message, may be transmitted automatically.

Said test signal, or message, may be transmitted in accordance with a predetermined schedule.

Each POTS splitter may have a unique identity code, and said unique identity code may be transmitted whenever a test signal, or message, is transmitted, or when ever an identification request signal is received.

Said test signal may be generated by short-circuiting a line.

Results obtained from line tests may be collected and stored at said central office and a log of line condition for each subscriber line may be derived therefrom.

A plurality of results obtained from line tests may be collected and stored at said central office and said plurality of results may be averaged to obtain a composite result for each subscriber line.

According to a fourth aspect of the present invention, there is provided a telecommunications system adapted to employ POTS and xDSL, comprising at least one central office connected to a plurality of subscriber premises by subscriber lines, at least some of said subscriber premises having a POTS splitter located therein, characterised in that said POTS splitter is a POTS splitter as set forth in any preceding paragraph.

According to a fifth aspect of the present invention, there is provided a telecommunications system adapted to employ POTS and xDSL, comprising at least one central office connected to a plurality of subscriber premises by subscriber lines, at least some of said subscriber premises having a POTS splitter located therein, characterised in that said POTS splitter is adapted to measure subscriber line quality in accordance with a method as set forth in anypreceding paragraph.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawing, in which:

Figure 1 illustrates an overview of the way POTS splitters are located in an xDSL system.

As previously explained, when delivering a broadband service such as xDSL, without inband POTS, it is necessary to separate the analog POTS signal and the xDSL signal from each other at both the CO (Central Office) and the CP (Customers Premises). This can be done with analogue passive high pass and low pass filters and is illustrated in schematic form in Figure 1 which shows an overview of the principle. Referring briefly to Figure 1, it will be seen that the CO has a rack of LICs (Line Interface Cards) which include POTS splitters for separating analogue telephony signals and xDSL signals received from subscribers. At the subscriber end, there is a POTS splitter which separates

analogue telephone signals and xDSL signals received from the CO. This scheme is equally applicable to passive and active POTS splitters.

Unfortunately, passive POTS splitters lack the performance of active splitters. This results either in:

- degradation of transmission; or
- loss of xDSL spectrum.

The use of an active POTS splitter with impedance matched circuits gives more reasonable filter design criteria and more efficient use of xDSL spectrum.

The present invention proposes to capitalise on the advantages of active splitters by incorporating test functionality, for the line between the CP and the CO, or ONU (Optical Network Unit), in the POTS splitter and, preferably, implementing both the POTS splitter and test functionality in a single chip. This enables two-sided measurements on the line to be performed both during installation and operation. These measurements can be performed from the CO end either on request, or when the test device automatically sends a test message/signal. This avoids the need for field technicians at the CP side when line measurements are performed. The chip can be provided with a unique identity code that can be transmitted to the CO when ever a test is performed, or requested. The identity code can be associated with test data thus enabling a line to which the test data relates to be uniquely identified

The test messages/signals are either specially designed for a certain measurement case or, alternatively, general test messages/signals such as pulses, steps, or chirps, that can be used to estimate the transfer function of the line. A parameter that demands two-sided measurement is attenuation. The test sequence can, in this case, be a series of sinusoidal signals, with known amplitude, sent from the test device to the CO in sequence. The sequence can, for example, comprise 10, or 100, or any other number of tones, starting from either low, or high, frequency and then going towards the other side of the frequency spectrum.

Each tone is sent out for a relatively long period of time, so that synchronisation is not a problem. This also guarantees that the measurement is completed within the duration of a tone. The test commences at a predetermined

time interval after receipt of a test message request.

Another valuable facility that can be provided by the test device is the ability to open, or short-circuit, the line at the CP side on request from the CO. This enables the well known open/short-circuit measurement method, see SR Olofsson, Anders Isaksson & Joachim Johansson, "MEASUREMENT METHODS FOR WIRE PAIRS IN THE ACCESS NETWORK", 7/0363/2/FCPA 1.090013,97-10-20, to be performed.

It is also possible to let the POTS splitter, located at the CP, generate a test signal every time the customer picks up the receiver, i.e. the telephone instrument changes from an "on-hook" state to an "off-hook" state. Measurements are performed on these signals at the CO and the results of the measurements accumulated. In this case the test signal can, for example, be a step, pulse, or even a chirp. It may even be possible to carry out these measurements without the test device by using the step signal that is generated whenever a telephone goes from an "on-hook" high impedance state to an "off-hook" low impedance state. However, if this method is to be used, care must, of course, be taken to handle the contact bounces that are generated. The central concept behind the invention is still to generate numerous test messages and to save the results at the CO.

Another possibility is to program the active POTS splitter to send certain test messages in accordance with a predetermined schedule. At the CO side the LIC:s (Line Interface Cards) must have the functionality needed to measure and process the generated "on/off-hook" signal. If many such signals are collected and saved over a long period of time, the result can be used as a log of the line condition. A result calculated from a large set of accumulated data, i.e. many hook lifts, will naturally have higher precision than a result based on a single measurement.

In a typical application of the present invention, a customer calls Telia's Customers Services Department, CSD, and requests that he/she be provided with Telia's newly announced "Superinternet Service" i.e. Telia's xDSL-service. The CSD tells the customer that they want to send him/her a test device, in other words, the active POTS splitter with line testing functionality, to check the quality of the line. When the customer receives the POTS splitter, he/she can instal it simply by inserting it in the telephony jack socket. It is then possible to perform measurements on the line from the CO. The results of these measurements can

then be promptly sent to the customer. It may then be possible to deliver the service from the next day or, alternatively, some minor, or major, changes may have to be made to the network before the customer can be provided with the requested service. The test device and POTS splitter, of the present invention, can be produced very cheaply because of chip integration. This means that it is not necessary to retrieve the test device and POTS splitter, from the customer, if the line quality is insufficient for the provision of an xDSL service.

POTS splitters that separate the analogue POTS signal and the xDSL signal from each other are, advantageously, active, because of the inadequate performance of passive designs. Active POTS splitters can be realised on a single chip, so that a POTS splitter solution only requires one IC on a simple circuit board. At very little additional cost it is possible to implement testing functionality on this chip. With this functionality it is possible to send test messages from the test device/POTS splitter at the CP, upon receipt of a request from the CO end. At the CO end, measurements of the line quality can then be performed. When a customer asks for a xDSL, or other copper line based broad band service, the test device/POTS splitter can be sent to the customer's home and the customer can then install the POTS splitter/test device himself. The test device/POTS splitter is a low cost device which means that it can be sent to customers free of charge and customers can be allowed to keep these devices even if measurements performedit is not possible to install any broad band service. It is also possible to automatically generate test signals from the test device/POTS splitter, e.g. on every "hook lift', in order to get large numbers of test results that are accumulated at the CO side, possibly on modified Line Interface Cards, thus yielding better estimates of the line condition.

CLAIMS

1. An active POTS splitter adapted to separate analogue POTS signals from xDSL signals, characterised in that said active POTS splitter incorporates line testing means.

2. An active POTS splitter as claimed in claim 1, characterised in that said testing means is adapted to transmit a test signal, or test message, to a line to be tested.

3. An active POTS splitter as claimed in either claim 1, or claim 2, characterised in that said test signal is adapted for the performance of a specific line test.

4. An active POTS splitter, as claimed in either claim 1, or claim 2, characterised in that said test signal is of a general form capable of use with a range of different line tests.

5. An active POTS splitter, as claimed in claim 4, characterised in that said test signal comprises at least one pulse.

6. An active POTS splitter, as claimed in claim 4, characterised in that said test signal comprises at least one step.

7. An active POTS splitter, as claimed in claim 4, characterised in that said test signal comprises at least one chirp.

8. An active POTS splitter, as claimed in claim 3, characterised in that said test signal comprises a series of sinusoidal signals of known amplitude, each signal in said series having a different frequency, said series spanning a frequency range for which a line is to be tested.

9. An active POTS splitter, as claimed in claim 8, characterised in that each tone of said series of sinusoidal signals has a duration of a length sufficient to avoid problems associated with synchronisation and to permit a measurement to be completed within said duration.

10. An active POTS splitter, as claimed in any of claims 2 to 8, characterised in that said test means is adapted to transmit said test signal, or message, on receipt of a request signal.

11. An active POTS splitter, as claimed in claim 10, characterised in that a test facilitated by said test means is initiated at a predetermined time interval after receipt of a request signal by said test means.

12. An active POTS splitter, as claimed in any of claims 2 to 11, characterised in that said test means is adapted to transmit said test signal, or message, automatically.

13. An active POTS splitter, as claimed in claim 12, characterised in that said test means is adapted to transmit said test signal, or message, in accordance with a predetermined schedule.

14. An active POTS splitter, as claimed in any previous claim, characterised in that said test means has a unique identity code, and in that said test means is adapted to transmit said unique identity code whenever a test signal, or message, is transmitted, or whenever an identification request signal is received.

15. An active POTS splitter, as claimed in any previous claim, characterised in that said test means is adapted to short-circuit a line.

16. An active POTS splitter, as claimed in any previous claim, characterised in that said active POTS splitter, including said test means, is implemented as a single chip.

17. An active POTS splitter, as claimed in claim 16, characterised in that said

chip is mounted on a PCB connected to a line jack adapted for direct insertion into a customer premises line socket.

18. In a telecommunications system adapted to employ xDSL and POTS, and comprising at least one central office connected to a plurality of subscribers by subscriber lines, a method of measuring quality parameters relating to xDSL transmission on a subscriber line, characterised by the steps of:

- generating a test signal on said subscriber line at a subscriber's premises;

- performing measurements at said central station on said test signal as received at said central station; and

- deriving quality parameters for said subscriber line from said measurements.

19. A method, as claimed in claim 18, characterised by generating said test signal by causing said subscriber line to change from a high impedance state to a low impedance state.

20. A method as claimed in claim 19, characterised by generating said test signal by causing a telephone to switch from an "on-hook" state to an "off-hook" state.

21. In a telecommunications system adapted to employ xDSL and POTS, and comprising at least one central office connected to a plurality of subscribers by subscriber lines, each subscriber premises being equipped with a POTS splitter, a method of measuring quality parameters relating to xDSL transmission on a subscriber line, characterised by the steps of:

- said POTS splitter generating a test signal on said subscriber line;

- performing measurements at said central station on said test signal

as received at said central station; and

- deriving quality parameters for said subscriber line from said measurements.

22. A method, as claimed in claim 21, characterised by said test signal being adapted for the performance of a specific line test.

23. A method, as claimed in claim 21, characterised by said test signal being of a general form capable of use with a range of different line tests.

24. A method, as claimed in claim 23, characterised by said test signal comprising at least one pulse.

25. A method, as claimed in claim 23, characterised by said test signal comprising at least one step.

26. A method, as claimed in claim 23, characterised by said test signal comprising at least one chirp.

27. A method, as claimed in claim 22, characterised by said test signal comprising a series of sinusoidal signals of known amplitude, each signal in said series having a different frequency, said series spanning a frequency range for which a line is to be tested.

28. A method, as claimed in claim 27, characterised by each tone of said series of sinusoidal signals having a duration of a length sufficient to avoid problems associated with synchronisation and to permit a measurement to be completed within said duration.

29. A method, as claimed in any of claims 21 to 28, characterised by transmitting said test signal, or message, on receipt of a request signal.

30. A method, as claimed in claim 29, characterised by initiating a test at a

predetermined time interval after receipt of a request signal.

31. A method, as claimed in any of claims 21 to 30, characterised by transmitting said test signal, or message, automatically.

32. A method, as claimed in claim 31, characterised by transmitting said test signal, or message, in accordance with a predetermined schedule.

33. A method, as claimed in any of claims 21 to 32, characterised by each POTS splitter having a unique identity code, and by transmitting said unique identity code whenever a test signal, or message, is transmitted, or when ever an identification request signal is received.

34. A method, as claimed in any of claims 21 to 33, characterised by generating said test signal by short-circuiting a line.

35. A method, as claimed in any of claims 18 to 34, characterised by collecting and storing results obtained from line tests at said central office and deriving a log of line condition for each subscriber line therefrom.

36. A method, as claimed in any of claims 18 to 34, characterised by collecting and storing a plurality of results obtained from line tests at said central office and averaging said plurality of results to obtain a composite result for each subscriber line.

37. A telecommunications system adapted to employ POTS and xDSL, comprising at least one central office connected to a plurality of subscriber premises by subscriber lines, at least some of said subscriber premises having a POTS splitter located therein, characterised in that said POTS splitter is a POTS splitter as claimed in any of claims 1 to 17.

38. A telecommunications system adapted to employ POTS and xDSL, comprising at least one central office connected to a plurality of subscriber premises by subscriber lines, at least some of said subscriber premises having a POTS

splitter located therein, characterised in that said POTS splitter is adapted to measure subscriber line quality in accordance with the method claimed in any of claims 18 to 36.

PW 00-01-201

ABSTRACT

Improvements in, or Relating to Telecommunications

When delivering a broadband service, such as xDSL, without inband POTS, it is necessary to separate the analogue POTS signal and the xDSL signal from each other at both the CO (Central Office) and the CP (Customer's Premises). This can be achieved by using an active POTS splitter . The present invention incorporates test functionality for the line between the CP and the CO, or ONU (Optical Network Unit), in the POTS splitter. This enables two-sided measurements on the line, both during installation and during operation. The measurements are performed at the CO end upon request, or when the test device automatically sends a test message/signal. In this way there is no need for field technicians at the CP side. The POTS splitter can have a unique identity code that is transmitted to the CO each time a test is started, or on receipt of a request from the CO.

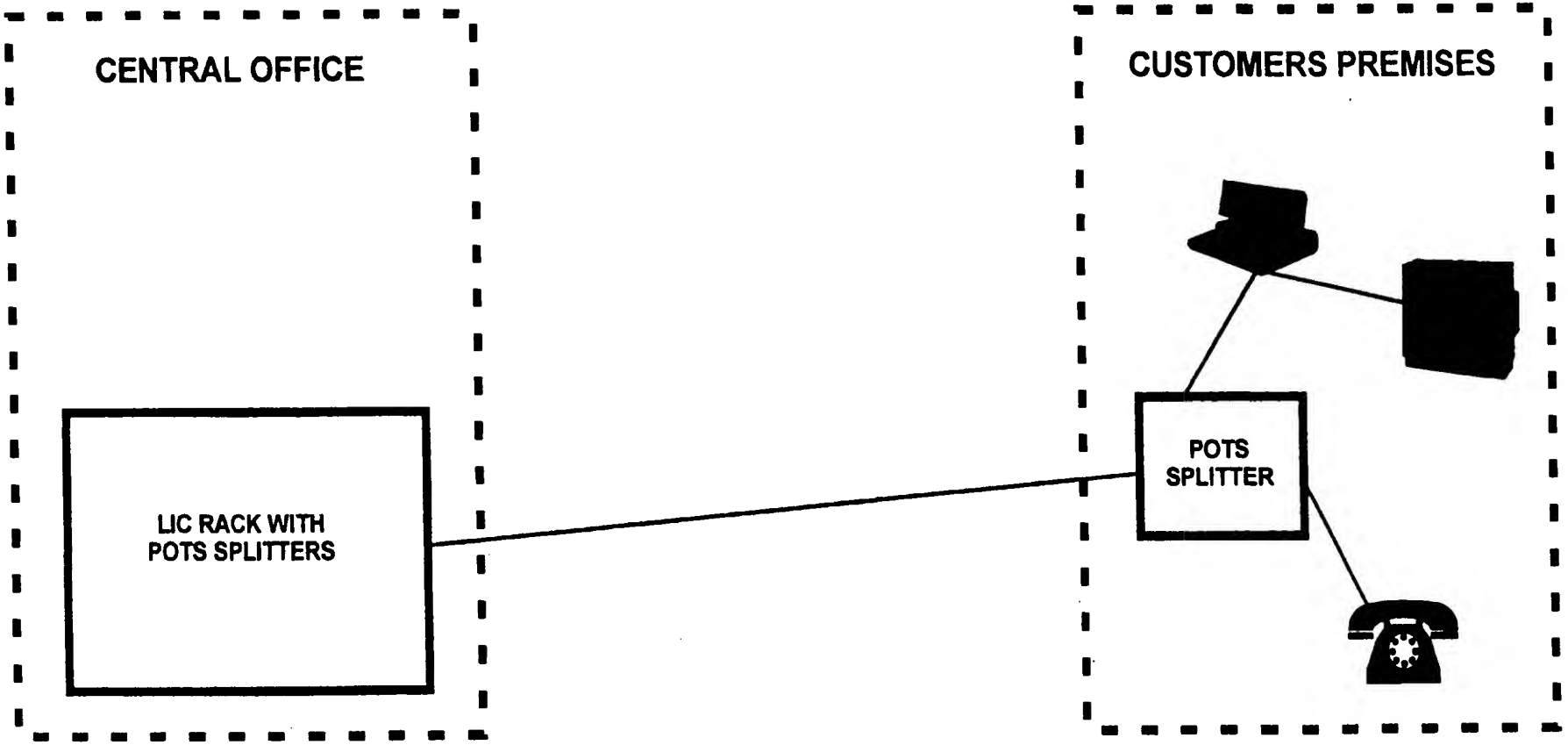
CENTRAL OFFICE
LIC RACK WITH
POTS SPLITTERS
CUSTOMERS PREMISES
POTS
SPLITTER

FIGURE 1